BIOLOGICAL EVALUATION OF THE EASTERN SPRUCE GALL APHID ON RED SPRUCE IN THE LIMBERLOST, SHENANDOAH NATIONAL PARK

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Introduction

A study on the biogeography of red spruce in the Shenandoah National Park by Keith and Julie Langdon indicated limited reproduction of red spruce and an infestation of the eastern spruce gall aphid in the Limberlost (Langdon and Langdon, 1981). Their study also mentioned high mortality of mature red spruce on Hawksbill Mt. Personnel from the Asheville Field Office, Forest Pest Management, were requested to do a biological evaluation in the Limberlost, an "outstanding natural area" in the Shenandoah National Park, to determine; 1) the impact of the spruce gall aphid on red spruce, and 2) what other factors, if any, might be contributing to the problem.

Life History and Habits of the Eastern Spruce Gall Aphid

The eastern spruce gall aphid (Adelges abieties [L.]) is a small, inconspicuous, soft-bodied insect. It secretes a filamentous, waxy substance which gives it a white, woolly appearance. Feeding by the aphid causes a reaction in the tree which leads to the formation of pineapple-shaped galls.

The major hosts of the spruce gall aphid are Norway spruce (Picea abies) and white spruce (Picea glauca). Other hosts include red spruce (Picea rubens) and Colorado blue spruce (Picea pungens) (Baker, 1972).

The spruce gall aphid overwinters as a nymph at the base of the bud. The nymphs are covered with waxy threads which give them the appearance of small tufts of wool. In the spring, the nymphs molt into wingless adult females, called stem mothers; no males have ever been observed. The females lay their eggs on the needles. After two weeks, the eggs hatch and the nymphs crawl to the bases of newly expanding buds where they feed. In response to feeding by the aphid, the needles and then the twigs expand until they have formed a case which encloses the feeding nymphs. The case or gall is distinctively pineapple-shaped. The nymphs continue to feed within the gall until late summer when the gall opens and the full grown nymphs emerge. These nymphs transform into winged female adults. Although the females are winged, they rarely fly to a different tree. Instead, they remain on the same tree and lay their eggs. After laying about 60 eggs, the female dies. Her body forms a covering for the eggs. The eggs hatch in about two weeks, and the nymphs crawl to overwintering sites (Baker, 1972; McDaniel, 1937; Plumb, 1950).

This insect rarely causes tree mortality. Branch dieback can occur if galls encircle the twig, cutting off transport of nutrients and water. Usually, galls only reduce the aesthetic value of the trees and, therefore are pests in nurseries, Christmas tree plantations, and on ornamentals. Heavy infestations are rarely found in forest stands. As with many insect pests, trees which are under stress and growing slowly on poor sites are more affected by the spruce gall aphid than trees exhibiting vigorous growth on good sites (Craighead, 1949).

Silvics of Red Spruce

Red spruce (Picea rubens Sarg.) is found from southeastern Canada to Pennsylvania and New Jersey, and in the Appalachian Mountains at elevations above 3500 ft. Red spruce attains maximum development in the Appalachians due to the high humidity and heavy rainfall in this area. This species is able to grow on a number of sites ranging from shallow soils on steep, rocky slopes to organic soils in wet, bottom lands. Red spruce is found mainly on what are considered marginal sites, because it can not compete with most species on good sites. Red spruce grows slowly and is easily overtopped when in competition with other species. Once it is shaded by other trees, it continues to grow, but very slowly.

Red spruce begins cone production at about 30 years of age, but in dense stands this can be delayed until the trees are 45 to 50 years old. It has a heavy seed crop every 3-8 years, with light crops in the intervening years. Seedfall occurs from October through March. Red spruce seed will germinate on almost any type of seedbed, provided the temperature is a favorable 68° to 86°F (Fowells, 1965).

The natural reproduction of red spruce depends mainly on factors controlling seedling survival. The seedbed is critical in the establishment of the seedling. For a seedling to become established the roots must be in contact with a constant moisture supply. Mineral soil is the best seedbed for providing this condition. Organic material is subject to rapid desiccation and is, therefore, unsuitable for seedling establishment. Red spruce seedlings have very slow growing, fiberous root systems. It has been found that roots which must travel through more than two inches of organic matter, where they are subject to fluctuating moisture conditions, usually die before reaching mineral soil. For these reasons, exposed mineral soil or mineral soil with a thin organic layer is necessary for seedling establishment. Red spruce has difficulty regenerating under itself in dense stands, because red spruce needles decompose slowly, thus forming an organic layer subject to desiccation and unsuitable for seedling establishment (Murphy, 1917).

Even when the appropriate seedbed is provided and the seedlings become established, there are still obstacles to further growth. Red spruce seedlings cannot survive under hardwoods because the layer of leaves smothers the seedlings. Increased temperature and humidity under the leaves causes the death of the seedlings. The growth rate in red spruce is strongly influenced by light. It is a shade tolerant species and can survive under low light for many years, but growth is very slow. Research has shown that red spruce grows much faster in the open than under shade (Murphy, 1917). Red spruce responds well to release, but the vigor of the response diminishes with age. This is a disturbance species, in the sense that something must happen which causes an opening in the stand allowing more light which promotes faster growth of the seedlings.

Red spruce is easily killed by fire due to its shallow root system, thin bark, and resinous exudations. It is also subject to windthrow, especially on thin and wet soils (Fowells, 1965).

Discussion

In the Limberlost, red spruce is growing in a dense mixed stand with yellow birch and hemlock. The hydrology of the area is not fully understood, but it can be described as an area of interlacing streams. It appears that there is an ample water supply in spite of the present drought. The mineral soil is overlain with several inches of partially decomposed organic material and a thin layer of undecomposed spruce needles. The mature red spruce hold dominant and co-dominant positions in the canopy. There was no obvious branch mortality or top dieback.

Some cones were found which had not opened yet. These were taken back to the lab and the seed extracted. Radiographs of the seed showed that 12 percent of the seeds were full and potentially viable. The cone analysis indicated about 8 full seeds per cone, which is well below the average 28 seeds per cone for red spruce (Schopmeyer, 1974). However, the sample was small and should not be considered representative of the entire population. The important point is that potentially viable seed is being produced. Evidence was found that squirrels had been feeding on the seed, which could be reducing the seed supply considerably.

Examination indicated there were no seedlings less than one meter high and very few saplings. The few seedlings and saplings found were lightly infested with the eastern spruce gall aphid. Woolly nymphs and distinctive galls confirmed their presence. Most of the seedlings were obviously stunted. Although age determination was not made, growth form was indicative of slow growth over a number of years. The stunted form could be attributed to inadequate light, which would restrict growth. Most of the regeneration which does occur is in semi-openings, which happen to be along stream edges. The soil in this area is quite unstable and susceptible to erosion. Many saplings along the streambank had fallen over and died, presumably because the root systems were so shallow.

In the 1800's, red spruce was found extensively in the area now comprising the Shenandoah National Park. By the turn of the century, extensive logging and subsequent fires had eliminated red spruce from most of the region. Red spruce was left only in inaccessible or fire resistant areas. It is possible that the Limberlost was one of these areas, and red spruce was able to persist there. Established trees continued growing, but seedbed and light conditions were or became unsuitable for seedling establishment and survival. This would bring us to the present situation where the majority of the stand is composed of mature red spruce with very few saplings or seedlings.

In the Limberlost, the site is not appropriate for successful red spruce regeneration. The organic layer is too thick for good seedling establishment, and there is not enough light to promote good growth on the seedlings that do survive. The weak, slow-growing trees are subject to attack by the eastern spruce gall aphid. Trees infested with the aphid may exhibit even slower growth, but the insect is not causing mortality of red spruce.

Recommendations

1. Do nothing and allow the situation to continue as it is.

If the land manager chooses to follow this recommendation, red spruce can be expected to persist as a major canopy species in the Limberlost for many years. However, there will continue to be a lack of natural regeneration, because the site is currently not suitable for red spruce seedling establishment and survival.

2. Promote red spruce regeneration.

The first step toward regenerating red spruce is create an exposed, mineral-soil seedbed. This can be accomplished by removal of the organic layer through mechanical means. A very cool, controlled burn might achieve the same ends.

An adequate seed supply must be available. If squirrels are depleting the seed supply, then the squirrels would have to be controlled. If there is not a sufficient natural supply of seed, then seed would have to be obtained elsewhere and planted.

In addition to seedbed preparation and seed source, openings must be created to provide enough light to encourage good growth of the newly established seedlings.

It is suggested that the Shenandoah National Park follow recommendation 1, because it is the least disruptive to the environment and is most compatible with current management objectives and policies.

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